9.4 DOE Code-Comparison Project, Problem 5, Case A

This problem involves multiphase flow in a 2-D horizontal reservoir. The problem is characterized by a moving two-phase region, i.e., the fluid produced at the production well is replaced by cold water recharge over one of the outer boundaries. The problem parameters are given in Table IX, and the geometry and boundary conditions are shown in Fig. 10. Of particular note are the variable initial-temperature field provided to the code through a read file (see Section 5.7 on page 10), and the prescribed pressure and temperature on the right boundary. A partial listing of the input file is provided in Fig. 11. In addition to the required macros, the macro **flow** is used to specify the pressure and temperature boundary condition and the production flow rate. Macro **rlp** is used to set the residual liquid and gas saturations.

Table IX. Input parameters for the DOE code-comparison project problem

Parameter	Symbol	Value
Reservoir permeability	k	$2.5 \times 10^{-14}\ \mathrm{m}^2$
Reservoir porosity	ϕ	0.35
Rock thermal conductivity	κ_r	$1\ \frac{\mathrm{W}}{\mathrm{m} \cdot \mathrm{K}}$
Rock density	ρ_r	$2563\ \mathrm{kg/m}^3$
Rock specific heat	C_r	$1010\ \frac{\mathrm{J}}{\mathrm{kg} \cdot \mathrm{K}}$
Reservoir length	x	300 m
Reservoir thickness	y	200 m
Liquid residual saturation	S_{lr}	0.3
Gas residual saturation	S_{gr}	0.1
Reservoir discharge	q_m	$0.05\ \frac{\mathrm{kg}}{\mathrm{m} \cdot \mathrm{s}}$
Initial Pressure	P_o	3.6 MPa
Production well coordinates:		$x = 62.5$ m, $y = 62.5$ m
Observation well coordinates:		$x = 162.5$ m, $y = 137.5$ m

Initial temperature distribution (T in °C, r in m):

$$T(x, y, 0) = \begin{cases} 240 & 0 \le r \\ 240 - 160\left(\frac{r-100}{200}\right)^2 + 80\left(\frac{r-100}{200}\right)^4 & 100 < r < 300 \\ 160 & r \ge 300 \end{cases}$$

where $r = \sqrt{x^2 + y^2}$

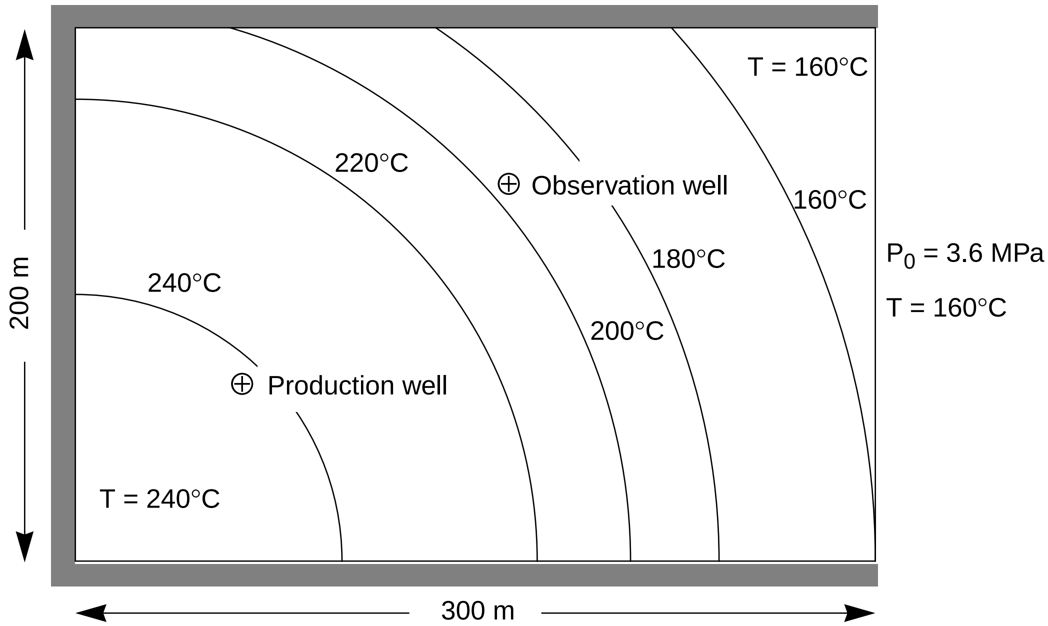

Figure 10. Schematic diagram of the geometry and boundary conditions for the DOE code-comparison project problem.

There is no analytical solution for this problem, but six researchers produced results for the DOE code-comparison project (Molloy 1980). The reader is referred to this reference for a more detailed discussion of this problem and the code comparison. Results from this problem are compared to those for the other codes, obtained from Molloy (1980), as a check on FEHM. The results for the outlet temperature, shown in Fig. 12, are in excellent agreement with the other codes. The results for the outlet pressure and pressure at an observation well 125 m distant (Fig. 13) are also in good agreement with the other codes. Contour plots of pressure and temperature at the end of the simulation were also generated for this problem and are shown in Fig. 14 and Fig. 15.

```
*** DOE Code Comparison Project, Problem 5, Case A ***
node
    2
    50  88
sol
    1    1
init
    3.6 0.240.      0.0.   240.0.      0.
rlp
    2    0.30.1      0.00.0

   1      140         1          1

rock
   1      140         1     2563.         1010.              0.35

cond
   1      140         1          1.00e-00     1.00e-00     1.00e-00

perm
   1      140         1          2.5e-14      2.5e-14      0.e-00

flow
  88       88         1          0.050       -25.00           0.
  14      140        14          3.600     -160.00           1.

time
    30.03650.100001000199403

ctrl
    40  1.e-0708
   1      140         1          1

    1.0  0.01.0
    40  1.20.1     60.
    1    0
coor
    140
    .
    .
    .
elem
    4    117
    .
    .
    .
stop
```

Figure 11. FEHM input file for DOE problem.

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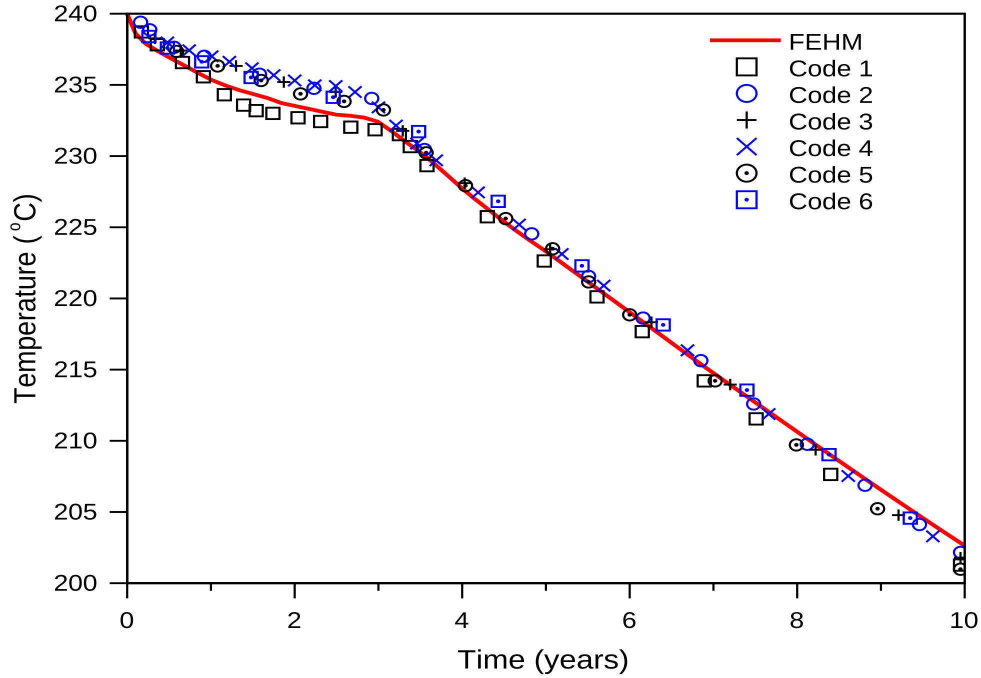

Figure 12. Comparison of FEHM production-well temperatures with results from other codes.

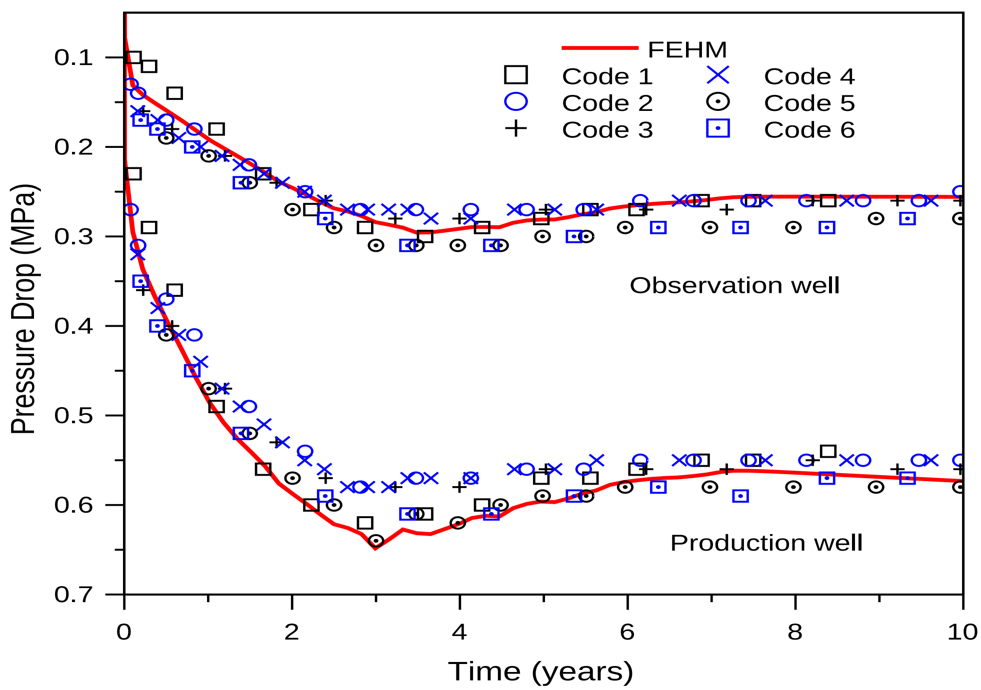

Figure 13. Comparison of FEHM production- and observation-well pressure drops with results from other codes.

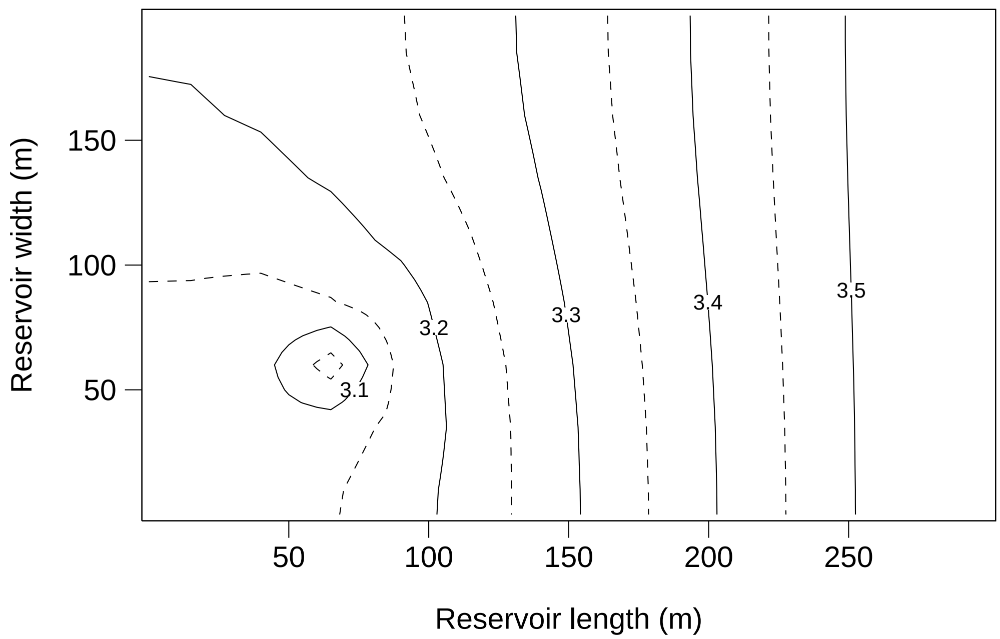

Figure 14. Contour plot of pressure at ten years for the DOE problem.

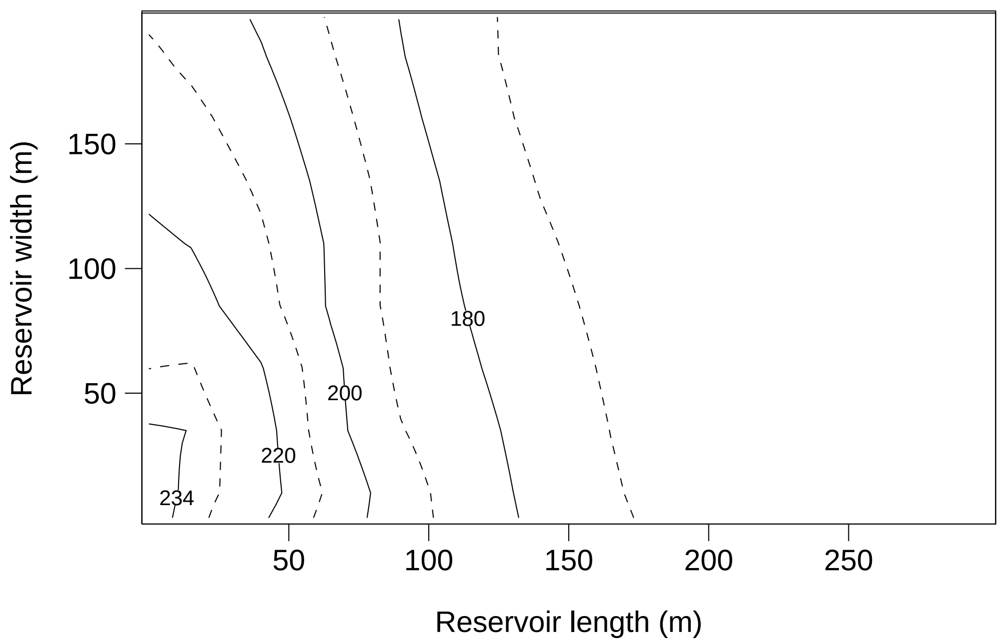

Figure 15. Contour plot of temperature at ten years for the DOE problem.